Parameter Design and Experimental Research of Vehicle Hydraulic Shock Absorber

Weihua Sun, Huajian Wang, Liping Xu

College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao 266590, China

Abstract

Cars are the most popular means of transportation in modern society, the auto industry has been rapid development, this situation has also led to the broad masses of people in addition to the requirements of automobile must have the most basic safety, but also put forward higher requirements on the vehicle comfort and stability, people's car just required a stable and relative comfort of vehicle vibration can effectively solution. The auto suspension system used in shock absorber is the most widely used hydraulic shock absorber, its working principle is done when the frame and axle back and forth relative motion, the piston reciprocates in the cylinder of the damper, oil damper shell will be repeated from the cavity through a number of small pores into another cavity, liquid molecules the internal friction and wall friction and molecular vibration damping force.The shock absorber is an integral part of the development of automobile, but also can ensure the vehicle comfort and stability in a certain extent, besides, it can also effectively avoid excessive damage to other parts, so the current in the automotive field for the study of shock absorber is very important.

Keywords

Automobile, hydraulic shock absorber, parameter design, experimental research.

1. Introduction

In the car, the device mainly used to connect the frame to the axle is the car suspension system[1]. In the suspension system of the car, the shock absorber is an important core component, which is mainly a damper that consumes vibration capability. And the two parts of the spring that can moderate the vibration. The impact of the road facing the frame determines the comfort level of the driving[2]. The main function of the shock absorber is to convert the energy generated by the vibration of the car into other modes of energy. The shock absorber can reduce the vibration of the vehicle caused by the sudden event to a certain extent. Therefore, the quality of the shock absorber can directly affect the function of the vehicle suspension system. The hydraulic shock absorber is when the body vibration piston squeezes the oil, it only causes small holes in the pressure of the high pressure relief valve, which causes a lot of heat. When the car vibrates, the air damper piston can compress the air and then The air vibration energy is discharged to the atmosphere[3].

This design includes the design of parameters such as the size of the two-cylinder hydraulic shock absorber, the design of the size and other parameters by determining the relative damping coefficient and determining the maximum unloading force, as well as the piston, piston rod, shock absorber hydraulic working cylinder, sealing components, etc. Verification of the size of the component. At the same time, the reliability and strength of the shock absorber after parameter design are checked[4]. The results of the verification should conform to the relevant national technical regulations. The main test methods of the two-cylinder hydraulic shock absorber are also discussed, and more advanced

experimental methods are found for the performance of the shock absorber. Through this design, the theoretical exploration of the shock absorber is further deepened, and the development of the shock absorber is further developed. It has a very important role. The purpose of this design is to contribute some reference to the manufacturing of automobile enterprises.

2. Parameter Design of Automobile Hydraulic Shock Absorber

Suspension shock absorbers are a very critical component in the automotive suspension system and are indispensable for the ride comfort, handling and stability of the vehicle. In the medium-sized car, the Honda Accord's shock absorbers are ordinary shock absorbers. This design uses the Honda Accord as an example to design shock absorbers[5].

Table 1. Technical parameters of Honda Accord

长×宽×高(mm)	4915×1845×1470
轴距(mm)	2775
最小离地间隙(mm)	100
整备质量(kg)	1512
前/后轮距(mm)	1595/1585

2.1 Calculation of Suspension Static Deflection

Suspension static deflection means that when the full-weight car is stationary, the load F on the suspension is divided by the suspension stiffness c at this time. One of the important indicators related to the ride comfort is the inherentity of the car suspension[6]. Frequency, the disturbance of vehicle fluctuations is directly related to the static deflection of the suspension.

$$f = \frac{F}{c} \tag{1}$$

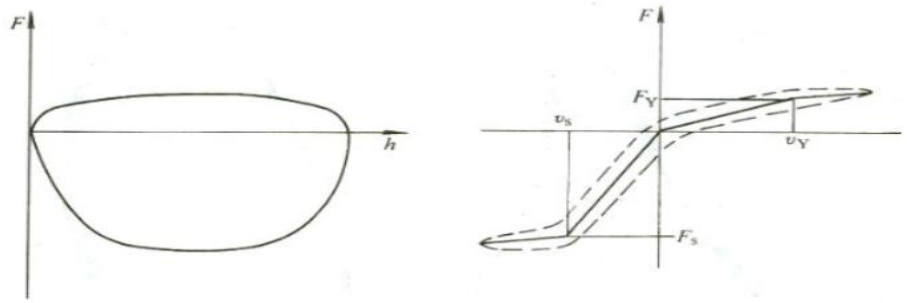
In the formula c is the suspension stiffness when the car is stationary; F is the load on the suspension.

$$\mathrm{n} = \frac{1}{2}\pi\sqrt{\frac{\mathrm{c}}{\mathrm{m}}} \tag{2}$$

In the formula, the stiffness of the front suspension of the Honda Accord; m the spring mass of the front suspension of the Honda Accord; n the offset of the front suspension of the Honda Accord, take n=1.0, combined with the formula, the suspension static deflection is mm .

2.2 Calculating the Relative Damping Coefficient

When determining the resistance characteristics of the shock absorber, the stability, maneuverability, and smoothness of the Honda Accord should generally be considered. The resistance value should reach the conditions specified by stability and maneuverability. Through the displacement performance line diagram of the resistance of the shock absorber and the speed performance line diagram of the resistance, the four important parameters of the shock absorber can be clearly understood[7]. In the absence of an exception, the damping coefficient of the shock absorber is generally the factor before the unloading door is opened. And the general damping coefficient is different from the compression process in the stretching process. In a sense, the degree of attenuation is usually measured by the relative damping coefficient.



a) 阻力一位移特性 b) 阻力一速度特性

Figure 1. Characteristics of the shock absorber

The relative damping coefficient is calculated using the following formula:

$$\varphi = \frac{\delta}{2\sqrt{\mathrm{cm}}} \tag{3}$$

Where c is the vertical stiffness of the automotive suspension system, m is the spring mass of the front suspension, and δ is the damping coefficient. In fact, the damping function of the shock absorber is directly related to the stiffness and the sprung mass. Different stiffness and sprung mass will have different damping. The degree of vibration is inversely proportional to the relative damping value, and the force generated when colliding with the road surface is transferred to the body of the car at this time; the smaller the relative damping value is, the reverse is[8].

2.3 Determine the Maximum Unloading Force

The maximum unloading force means that after the piston speed of the damper increases to a prescribed value and remains constant, the unloading valve is opened correspondingly. At this time, the unloading speed is the moving speed of the corresponding piston, and the maximum unloading force is the corresponding load of the piston. . The unloading rate is generally 0.15~0.30m/s, and the unloading speed formula is:

$$V = A\omega\cos\alpha \tag{4}$$

In the formula, A represents the vibration amplitude of the Honda Accord, the value is ±40mm; a represents the distance between the contact point on the crossbar of the shock absorber and the body, the value is 780mm, so you can know *v*=0.17m/s.

The maximum unloading force formula is:

$$F = cV\xi \tag{5}$$

In the formula, c is the impact load factor, and 1.5 is selected.

2.4 Determine the Diameter of the Hydraulic Cylinder

The cylinder diameter is calculated according to the maximum unloading force. Determined by the following formula:

$$D = \sqrt{\frac{4F}{\pi\, p\left(1-\lambda^2\right)}} \tag{6}$$

Where p is the maximum pressure value allowed for the hydraulic cylinder, choose (3 ~ 4) Mpa; this time the value is 3.5, λ is the diameter of the connecting rod divided by the diameter of the cylinder, the double cylinder hydraulic shock absorber is usually used. This design is taken as 0.4. The result of the calculation is obtained. The calculated result is the theoretical value of the hydraulic cylinder diameter, and the diameter of the hydraulic cylinder is approximately taken as the standard diameter. The thickness of the selected wall is 2 mm, which is made of steel No. 20.

Table 2. Cylinder Damper Working Cylinder Diameter (mm)

工作缸直径					
20	30	40	45	50	65

Table 3. Compressive resistance of recovery resistance (N)

工作缸直径(mm)	复原阻力	压缩阻力
20	200—1200	不大于600
30	1000—2800	不大于1000
40	1600—4500	400—1800
45	2500—5500	600—2000
50	4000—7000	700—2800
65	5000—10000	1000—3600

Since the working cylinder diameter D=30mm of the shock absorber is known in the prior art, according to Table 2.3, the recovery resistance of the shock absorber is between 1000-2800 and the compression resistance is not more than 1000, and the approximate recovery resistance and compression resistance can be determined. They are 1800N and 700N respectively[9].

3. Discussion on Main Test Methods of Hydraulic Shock Absorber

The shock absorber is one of the important components of the car suspension system, and its performance will directly affect the reliability and safety of the car operation. Therefore, in the process of production and assembly, the shock absorber must be tested very strictly. The following is a discussion on the experimental method of the hydraulic shock absorber.

3.1 Indicator Diagram

The kinetic energy conversion speed of each node during the entire node conversion process can be performed by the following formula:

$$v = \frac{\pi sn}{6} \times 10 \tag{7}$$

Most foreign cars are generally multi-point detection in the detection of speed nodes, but in China, single-point detection is still implemented. Pass the table below. It can be seen that the speed control points of the test dampers are currently in several foreign countries.

Table 4. Speed control points for national test dampers

US	0.005	0.052	0.13	0.26	0.39	0.52	1.04
UK	0.005	0.052	0.13	0.26	0.39	0.52	1.04
Germany	0.005	0.052	0.13	0.26	0.39	0.52	0.9
Japan	0.005	0.1	0.3	0.63	1.0	1.5	

It can be seen from the above that most of the hydraulic shock absorbers are used unconventionally during the routine node detection. The speed nodes of these hydraulic shock absorbers generally do not exceed ten percentage points. Then need to increase.

3.2 Rate Performance

The rate performance experiment is a routine test of a hydraulic shock absorber. The rate performance line diagram shows that the hydraulic shock absorbers have different rates and the resistance values are different. The hydraulic damper can obtain the speed performance line graph through the electric dynamometer, and then determine the valve opening point, and then determine whether the selection of the opening valve meets the design requirements.

The rate performance line graph shows the change in the resistance of the Honda Accord hydraulic shock absorber. When designing the suspension and shock absorber, it is necessary to specify the trend of the speed performance line graph. From the design of the shock absorber, there is a certain mathematical relationship between resistance and velocity. If the relationship between force and velocity conforms to the formula in the actual process, further testing is needed.

3.3 Durability

The durability test is also the basic test of the hydraulic shock absorber, and an excitation method can be used. The general bench durability test stipulates that the durability test of the dynamometer in the range of seventy degrees to one hundred degrees should be kept normal, and some parts must not be destroyed.

In China, the car is usually set in more than one million times during the setting of the shock absorption. The test of the whole car speed is 0.55 times per second. In this process, the experiment of adding the force measurement cannot be performed. Make a decision. During the middle of the experiment, the rate of change of resistance was changed by the resistance of the entire hydraulic shock absorber. In Japan, in the test of shock absorption standards, it is 0.06 per second. And the size of the entire lateral direction generally fluctuates around 30%.

4. Conclusion

（1）The durability test is also the basic test of the hydraulic shock absorber, and an excitation method can be used. The total bench durability test stipulates that the durability test of the dynamometer in the range of seventy degrees to one hundred degrees should be kept normal, And some parts must not be destroyed.

In China, the car is usually set in more than one million times during the setting of the shock absorption. The test of the whole car speed is 0.55 times per second. In this process, the experiment of adding the force measurement cannot be performed. During a middle of the experiment, the rate of change of resistance was changed by the resistance of the entire hydraulic shock absorber. In Japan, in the test of shock absorption standards, it is 0.06 per second. And the size of The entire lateral direction generally fluctuates around 30%.

（2）Through the test and test of the performance of the hydraulic shock absorber, the design and analysis of the hydraulic shock absorber design will be further detailed to further reduce the development level of China and developed countries. The discussion on the performance of hydraulic shock absorbers can improve the capacity of our country's automobile production and reduce the production cost of automobiles, which has an indelible effect on the further growth of China's economy.

References

[1] Cai Gangchu. Design and Mechanical Analysis of Triangle Rubber Tracked Wheel Chassis of Camellia Fruit Picking Machine [D]. Central South University of Forestry and Technology, 2014.
[2] Li Kun. Research on Electro-hydraulic Servo Test Bench for Automobile Shock Absorber [D]. Zhengzhou University, 2014.
[3] Yao Xuefei. Research on key technology of automobile damper cylinder cylinder hot spinning equipment [D]. Liaoning University of Technology, 2015.
[4] Zhang Xin. Design and Research of Automatic Assembly Machine for Shock Absorber Bottom Valve [D]. Liaoning University of Technology, 2015.
[5] Yang Yu. Research on electric braking characteristics of electric motor driven by hub motor [D]. Jilin University, 2013.
[6] Liu Xiaojing. Mathematical modeling and simulation analysis of damping force of motorcycle shock absorber [D]. Jiangsu University of Science and Technology, 2013.

[7] Jin Libo. Application of magneto strictive displacement sensor in automobile shock absorber [D]. Zhengzhou University, 2013.
[8] Liu Jianxun. Research on design technology of nonlinear rubber suspension system for heavy trucks [D]. Tsinghua University, 2014.
[9] Hu Chong. Research on mechanical properties of automobile electromagnetic eddy current damper [D]. Hefei University of Technology, 2014.